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I, LEANNE MYNOTT, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PP 5943 for a patent by M.I.M. HOLDINGS LIMITED filed on 15 September 1998.



WITNESS my hand this
Nineteenth day of October 1999

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AUSTRALIA

PATENTS ACT 1990

PROVISIONAL SPECIFICATION

FOR THE INVENTION ENTITLED:-

"COLLECTORLESS FLOTATION"

The invention is described in the following statement:-

TECHNICAL FIELD

The present invention relates to froth flotation and particularly, but not only, flotation processes which reduce the quantity of collector required.

BACKGROUND ART

5 Froth flotation is a well-known process for separating valuable minerals from the remaining gangue in a mineral ore body. To obtain the valuable mineral, the ore is firstly ground, for example, in an AG, SAG or rod mill which is often followed by further grinding in a ball mill. The resultant slurry is then passed through a particle sizing apparatus such as a cyclone to limit the size of the particles to a predetermined value eg
10 0.1-.05 mm.

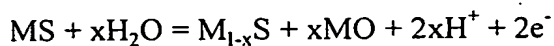
Traditionally, collectors, frothers, activators and various other additives are added to the slurry prior to its entry into the rougher/scavenger circuit where the desired valuable mineral is floated off from the remaining tail. The resultant concentrate is then fed to a cleaner/re-cleaner flotation circuit to undergo further processing. Optionally, more
15 collector/frother may be added at this time and the slurry may be reground prior to entry into the cleaner/re-cleaner circuit.

It is vital to successful flotation to maintain the hydrophobic nature of at least the surface of the valuable sulphide mineral. This is ordinarily accomplished by adding an

anionic collector to the slurry. It is important, however, to add the correct collector and in
20 the correct amount.

There has to date been several previous studies in regard to collectorless flotation of minerals, for example, chalcopyrite. If chalcopyrite ore is broken in a clean environment and subjected to flotation with air in an aqueous environment, it has been shown to form a metal deficient sulphide. If the material is oxidised further it is believed that it forms iron

hydroxide and elemental sulphur. The form of the equation for some metal sulphide minerals in alkaline environments is as follows:

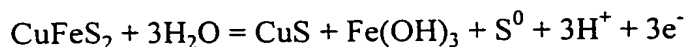


If the metal sulphide is oxidised further then the sulfur ends up being elemental sulfur as shown in the following equation:



The metal deficient sulphide $M_{1-x}S$ and the sulfur element S^0 are the hydrophobic species. Flotation can happen as long as the metal oxides/hydroxides formed by the reaction are solubilised. Excessive oxidation can produce thiosalts and ultimately sulphate. These ions together with the metal ions may react and re-adsorb as hydrolysis products on to the mineral producing hydrophilic surfaces.

With chalcopyrite the equation forming the sulfur element is:



The collectorless flotation of chalcopyrite requires that the flotation occurs in a neutral or slightly oxidising environment. Previous studies have shown that freshly fractured flotation of chalcopyrite increased when the Eh was in the neutral or slightly oxidising region. The flotation process also requires that the surface of the minerals being floated be as clean as possible. Previous studies have compared the effects on flotation recovery of a freshly fractured sulphide mineral versus an ore air oxidised for three weeks. The result was that the air oxidised minerals did not achieve the same recovery as the freshly fractured minerals.

Accordingly, it would appear that collectorless flotation of sulphide minerals is less likely to proceed unless the mineral surfaces are clean and the flotation is conducted in an

oxidising environment. There are a number of situations which may cause the surfaces of mineral not to remain clean including:

- iron ions (from metal balls or mill liners) in solution after the ore has been through the ball mill. These ions may then form hydroxide which may deposit on the surface of the minerals,
- recycled water containing ions that eventually react with metal ions in the system and then re-adsorb on the surfaces of the minerals.

There are a number of techniques which have been previously attempted to reduce the amount of these materials remaining on the surfaces of the particles including high intensity conditioning vessels and cleaning agents like sodium sulphide. Collectors like xanthate have also been suggested to perform the function of cleaning the surface of the minerals of these hydroxides in the first instance. Once the surfaces have been cleaned, the sulphide mineral can float due to the collector which attaches to the mineral making it hydrophobic.

As mentioned above, although there is some dispute, it is generally thought that collectorless flotation of certain sulphide minerals require an oxidising environment.

All flotation machines can be arranged to provide an oxidising environment required by the reaction to render the sulphide mineral particles hydrophobic. However, as

indicated above, if oxidation proceeds too far, thiosalt and eventually sulphate may form from the sulfur oxidation which may react with a metal ion in the solution forming metal sulphide.

This is a perennial problem with conventional production mechanical flotation cells when attempting collectorless flotation. The residence time for a typical mechanical cell is about three to five minutes. This long residence time and the increased Eh in a mechanical

cell causes excessive oxidation of the slurry thereby producing hydrolysis products which deposit on the surface of the minerals and may render them hydrophilic in nature ie difficult to float.

The present invention seeks to overcome at least some of the disadvantages of the prior art or provide a commercial alternative thereto.

DISCLOSURE OF THE INVENTION

In a first aspect, the present invention provides a process for recovery of a valuable sulphide mineral comprising the steps of:

- a) grinding a mineral ore to provide a slurry containing the valuable sulphide mineral at a particular predetermined particle size,
- b) feeding the slurry to a pneumatic flotation cell, and
- c) subjecting the slurry to flotation in the pneumatic flotation cell at such a speed that a normally required quantity of collector is not required to effect beneficiation of the valuable sulphide mineral.

In a preferred embodiment, flotation in the pneumatic flotation cell is conducted in a slightly oxidising environment.

In another preferred embodiment, the residence time in the pneumatic cell is below about two minutes, preferably between one and two minutes and most preferably between one and 1.5 minutes.

The inventive process may be conducted to reduce the quantity of collector needed or indeed totally eliminate the quantity of collector.

Most preferably, the pneumatic flotation cell is a Jameson cell.

In another aspect, the present invention provides a method of reducing collector use in a mineral beneficiation process comprising providing a pneumatic flotation cell

upstream of a rougher/scavenger and/or cleaner/re-cleaner circuit and subjecting a slurry to flotation in the pneumatic cell, a resultant concentrate from the pneumatic cell being fed to the rougher/scavenger and/or cleaner/re-cleaner circuit, wherein flotation in the pneumatic cell is conducted at such a speed that a normally required quantity of collector is not
5 required to effect beneficiation of a valuable sulphide mineral in the slurry.

The applicant has found that pneumatic cells such as the Jameson cell subject of Australian patent no 677,542, is ideal for reducing or even eliminating the use of collectors in the flotation of sulphide minerals. Typical pneumatic cells have residence time of less than two minutes, preferably around one to two minutes and most preferably one to 1.5
10 minutes. They can provide the slightly oxidising environment needed for collectorless flotation while effecting rapid flotation so as to avoid excessive oxidation or increase of the Eh where hydroxides are formed on the surface of the minerals.

The process kinetics of pneumatic cells eg Jameson cells, in particular, bubble production and attachment to the particles, are much quicker than conventional mechanical
15 cells. To explain, in a Jameson cell downcomer, the bubbles are created, collide with the particles and attach to the hydrophobic surface of the valuable sulphide mineral particles in approximately 30 seconds.

The slurry then leaves the downcomer and enters a separation tank where the

valuable sulphide mineral particles with the bubbles already attached quickly separate from
20 the remainder of the slurry eg approximately one minute.

Mechanical cells on the other hand require bubbles to be created by a mechanical means eg an impeller. The bubble collision and attachment steps as well as the separation process all occur within the same tank. This requires a much greater residence time to allow the bubbles to be created, attached to the particles and then separate from the slurry.

This greater residence time simultaneously increases oxidation and Eh of the slurry thereby reducing the effectiveness of collectorless flotation.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

So that the present invention may be more clearly understood it will now be
5 described by way of the following example, or flotation at reduced collector levels.

In order to show how fast the materials float, laboratory flotation tests were conducted using laboratory flotation cells. For the purpose of this example ore from Site A was used. The water used for the flotation study was the plant recycled water. Samples were taken between 0-30, 30-60, 60-90, 90-120 and 120-180 seconds.

10 Tables 1 and 2 below show the results of the flotation study. It can be seen that significant recovery is achieved even in the first 30 seconds of flotation. This grade of the product was also high indicating the non-flotation of pyrite.

The behaviour of this ore, a portion of which is chalcopyrite, indicates that this ore can easily be floated in a pneumatic flotation cell such as the Jameson cell.

15 While not wishing to be bound by any particular theory, the applicant believes that if the pulp potential of the slurry can be maintained at or near neutral and slightly oxidising condition as well as near neutral or slightly alkaline environment, then chalcopyrite can be made to float rapidly. The applicant believes that pneumatic cells and, in particular,

Jameson cells, may be used successfully for ores containing chalcopyrite (CuFeS_2) and
20 chalcocite (Cu_2S) as a cell operates under a very short residence time. Where the ore contains both chalcopyrite and chalcocite the applicant has found that collector aided flotation may be appropriate. To explain, chalcopyrite may be floated in a "collectorless" mode using S^0 with the chalcocite being floated using a non-xanthate collector. This will in turn minimise the flotation of pyrite minerals.

The present invention may be used separately or in conjunction with other mechanical cells. For example, the slurry may be initially treated by the pneumatic cell, as a scalper, producing a high grade concentrate. The tailings of the pneumatic cell can then be treated by mechanical rougher-scavenger cells. The scalper concentrate may be of
5 suitable quality that it may be directed to final concentrate product stream.

While it is possible to reduce the residence time of mechanical cells to avoid the aforementioned over oxidation/high Eh problems, this substantially increases the capital cost for the flotation circuit. As mentioned above, mechanical cells have an approximate residence time of around three to four minutes. If it is desired to reduce the residence time
10 to say two minutes, it will be necessary to reduce the size of each flotation cell which in turn will require an increase in the number of cells to maintain the same throughput. This will vastly increase the capital cost in the plant. It will be appreciated by persons skilled in the art that the simple addition of a pneumatic cell to effect collectorless flotation has a number of benefits including reducing or avoiding the costs associated with collector
15 usage, avoiding the substantial increase in costs which would be required using conventional mechanical cells, reduce power consumption and give better control.

Figure 1 is a flow sheet of a mineral beneficiation process using the present inventive method.

Feed stream 10 is fed to a Jameson cell 50. Jameson cell 50 acts a scalper. The
20 concentrate 52 is fed to the final concentrate stream 100. The tails 53 leaving the Jameson cell are fed to a primary rougher 70. The rougher tail 73 is fed to the final tail stream 200. The concentrate 72 is reground in mill 80. The reground concentrate 82 is then fed to a second Jameson cell 60 which acts as a scalper for the cleaner circuit. The tail 63 leaving

the Jameson cell is fed to a cleaner/scavenger cell 90. The concentrate 62 leaving the Jameson cell 60 is fed to final concentrate stream 100.

In the cleaner/scavenger cell 90, the concentrate 92 is recycled back to mill 80 for regrinding and feeding to the Jameson cell scalper 60. The cleaner/scavenger tails 93 is fed
5 to the final tail stream 200.

While the present invention has been described by way of reference to Jameson cells, any pneumatic flotation apparatus may be used for the present invention, for example, EKOF cell, Bahr cell, contact cell etc.

It will be clear to persons skilled in the art that the present invention may be
10 embodied in forms other than that specifically described herein without departing from the spirit or scope of the invention.

DATED this 15th day of September 1998

MIM HOLDINGS LIMITED

15 Attorney: PAUL G. HARRISON
Fellow Institute of Patent Attorneys of Australia
of BALDWIN SHELSTON WATERS

TABLE 1

FLOTATION TEST 1 - CHALCOPYRITE ORE FROM SITE A

PRODUCT	WT (GRS)	%Cu	%Fe	%Mo	Dist. Cu	Dist. Fe	Dist. Mo
0-30" Con	36.2	32.30	13.60	0.53	76.63	40.76	29.12
30-60" Con	9.2	16.40	8.35	1.18	9.89	6.36	16.48
0-60" Cum Con	45.4	29.08	12.54	0.66	88.52	47.12	45.6
60-90" Con	7.4	3.47	2.09	1.16	1.68	1.28	13.03
0-90" Cum Con	52.8	25.49	11.07	0.73	88.20	48.40	58.63
90-120" Con	5.7	2.58	1.14	0.76	0.96	0.54	6.58
0-120" Cum Con	58.5	23.26	10.10	0.73	89.17	48.94	85.20
120-180" Con	6.5	0.81	0.51	0.86	0.35	0.27	8.48
0-180" Cum Con	65.0	21.01	9.14	0.75	89.51	49.21	73.69
Nonfloat	1333.5	0.12	0.46	0.013	10.49	50.79	26.31
HEADS	1398.5	1.09	0.86	0.047	100.00	100.00	100.00

5

Test 1 Conditions

	pH	ORP (mV)
CONDITIONING	11.10	9
Flot 0-30"	11.05	-28
Flot 30"-60"	11.03	-13
Flot 60"-90"	11.00	-6
Flot 90"-120"	10.95	0
Flot 120"-180"	10.69	12
NONFLOAT	11.10	-29

TABLE 2

FLOTATION TEST 2 - CHALCOPYRITE ORE FROM SITE A

5

PRODUCT	WT (GRS)	%Cu	%Fe	%Mo	Dist. Cu	Dist. Fe	Dist. Mo
0-30" Con	34.5	31.60	15.20	0.61	75.25	29.35	31.24
30-60" Con	9.9	15.60	9.50	1.13	10.66	5.26	16.61
0-60" Cum Con	44.4	28.03	13.93	0.73	85.91	34.61	47.84
60-90" Con	6.7	4.11	3.74	1.15	1.90	1.40	11.44
0-90" Cum Con	51.1	24.90	12.59	0.76	67.81	36.02	59.28
90-120" Con	5.5	1.68	1.26	0.82	0.64	0.39	6.69
0-120" Cum Con	56.6	22.64	11.49	0.79	88.44	36.40	65.98
120-180" Con	6.2	0.91	0.62	0.87	0.39	0.22	8.01
0-180" Cum Con	62.8	20.49	10.42	0.79	88.83	36.62	73.98
Nonfloat	1348.2	0.12	0.84	0.013	11.17	63.38	26.02
HEADS	1411.0	1.03	1.27	0.046	100.00	100.00	100.00

Test 2 Conditions

	pH	ORP (mV)
CONDITIONING	11.10	-2
Flot 0-30"	11.02	-24
Flot 30"-60"	11.08	-9
Flot 60"-90"	10.96	-1
Flot 90"-120"	10.93	2
Flot 120"-180"	10.91	11
NONFLOAT	11.02	-25

TABLE 3

CURRENT PLANTS ASSAYS FOR SITE A USING
MECHANICAL FLOAT CELLS

5

		% Cu	% Fe	% Mo
Plant assays during sampling	Feed	1.13	1.24	0.093
	Prim Con	17.8	10.7	0.640
	Final Con	34.7	20.3	1.050
	Tails	0.17	0.50	0.010
Plant assays for day shift	Feed	1.29	1.24	0.054
	Prim Con	13.00	11.60	0.710
	Final Con	34.6	19.10	1.160
	Tails	0.13	0.45	0.009

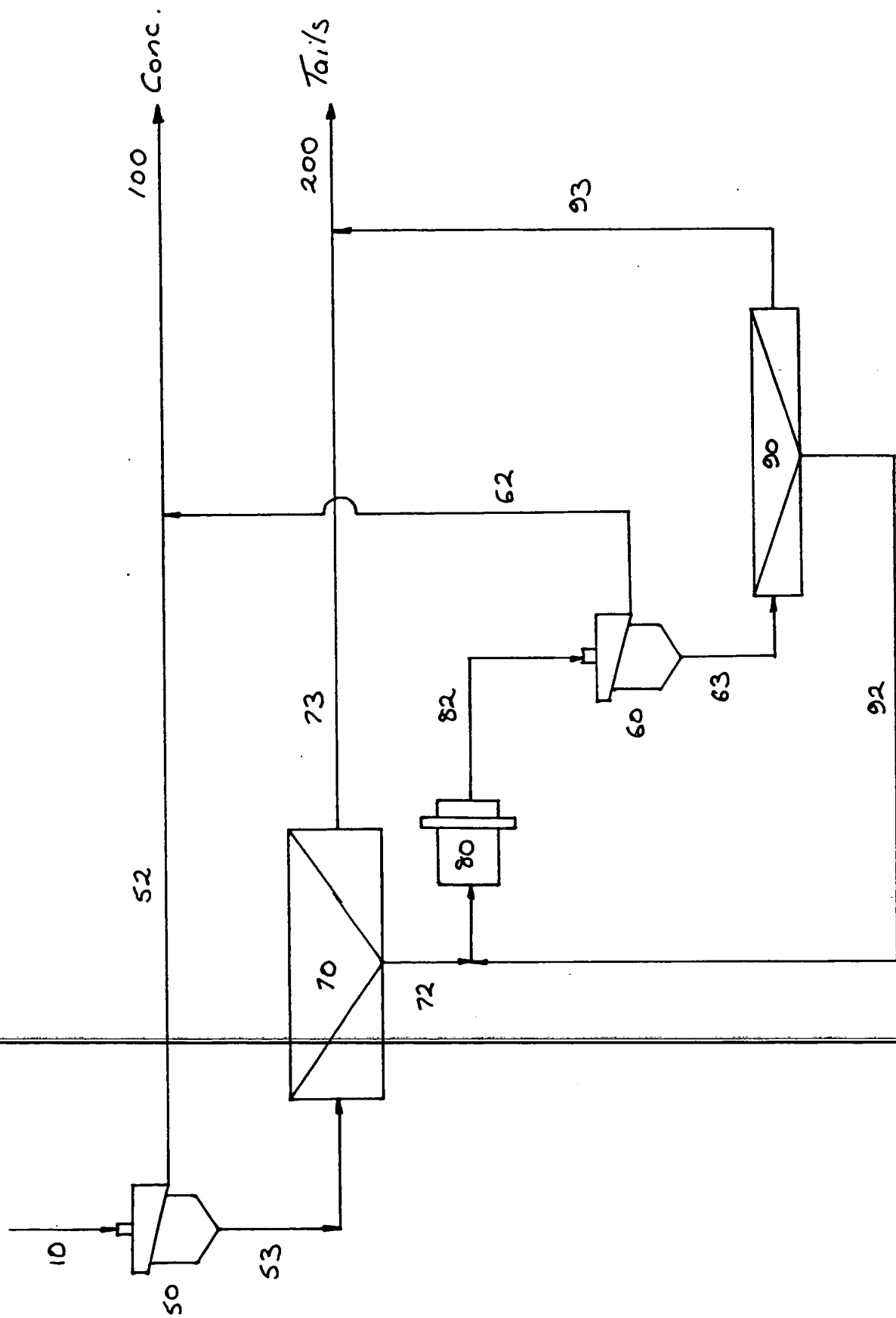


Figure 1